COPPERWOOD PROJECT
Orvana Resources US Corp.

Alternatives Analysis for MDEQ Application for Permit
MDEQ File No. 12-27-0001-P

May 15, 2012

1.0 Introduction

This Alternatives Analysis, on behalf of Orvana Resource US Corp. ("Orvana"), is primarily based upon Section 202.6 of the *Environmental Impact Assessment* that was completed as part of the permit application for Part 632, Non-Ferrous Metallic Mining Regulations, Public Act 451 of 1994, as amended. The complete Mine Permit Application is available and may be viewed on the MDEQ-GSD website at: http://www.michigan.gov/deq/0,4561,7-135-3311_4111_18442-262826--,00.html (or http://www.Michigan.gov/deq >Land>Oil, Gas and Minerals>Mining>Orvana Copperwood Project and select link for Part 632 application).

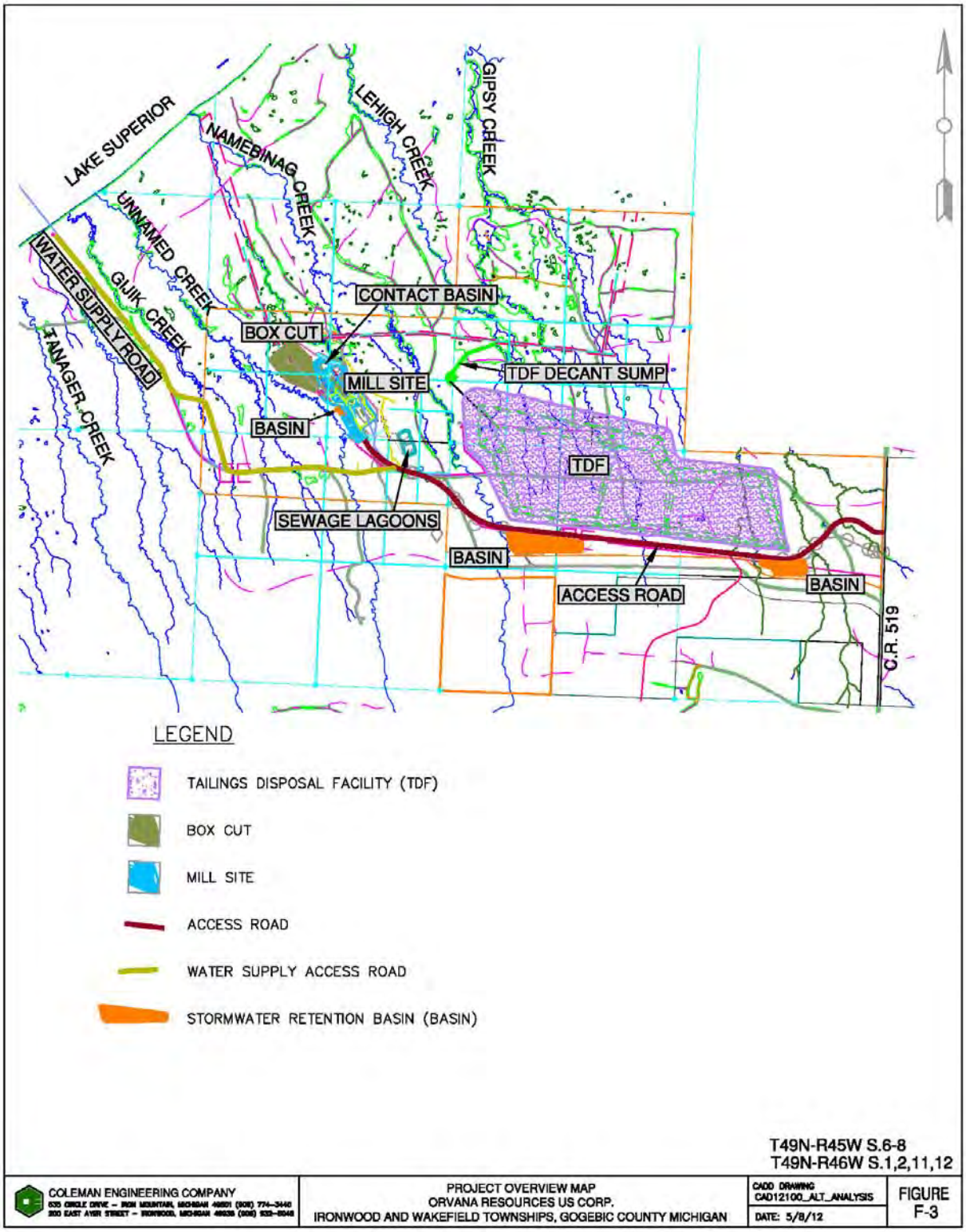
There are six activities associated with the Copperwood Project that require a permit under Part 303 (Wetland Protection) or Part 301 (Inland Lakes and Streams) of the Natural Resources and Environmental Protection Act, Public Act 451 of 1994, as amended (NREPA). Those six activities are (Figure 1-1):

- Underground mine entrance (box cut);
- Mill Site;
- Tailings Disposal Facility (TDF);
- Access road;
- Stormwater detention basins; and,
- Water supply access road

The alternatives for each of the preceding six activities are presented in this document.

2.0 Project Purpose

The project purpose has ramifications for review of alternatives for the project. The project purpose is not supposed to be so narrowly defined so as to limit the review of alternatives. The proposed project purpose for this project is: **construct an underground copper mine and related above-ground facilities.**


LAKE SUPERIOR
NAMEBINAG CREEK
LEHIGH CREEK
GIPSY CREEK
UNNAMED CREEK
GIJIK CREEK
WATER SUPPLY ROAD
TANAGER CREEK
CONTACT BASIN
BOX CUT
MILL SITE
TDF DECANT SUMP
BASIN
TDF
SEWAGE LAGOONS
BASIN
ACCESS ROAD
BASIN
C.R. 519
LEGEND
TAILINGS DISPOSAL FACILITY (TDF)
BOX CUT
MILL SITE
ACCESS ROAD
WATER SUPPLY ACCESS ROAD
STORMWATER RETENTION BASIN (BASIN)
T49N-R45W S.6-8
T49N-R46W S.1,2,11,12
COLEMAN ENGINEERING COMPANY
PROJECT OVERVIEW MAP
ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN
CADD DRAWING
CAD12100_ALT_ANALYSIS
DATE: 5/8/12
FIGURE
F-3
I:\JOB FILES\CAD Projects\CAD12100 Orvana\DWG\Figure 1-1 Project Overview Map.dwg

3.0 Underground Mine Entrance (Box Cut)

Five access options for mine access have been evaluated by two mining consulting engineering firms. Marston evaluated three box cut options, one of which was discarded, and Thyssen Mining (TMCC) evaluated a shaft option and a combination ramp and shaft option. A comparison of the costs of these options is shown in Table 3-1.

Table 3-1. Comparison of Mine Access Development Costs

Option	Shaft	Ramp	Cut-and Cover	Box Cut
Evaluated By	Thyssen Mining	Thyssen Mining	Marston	Marston
Estimates From	Thyssen Mining	Thyssen Mining	Local Contractors	Local Contractors
Mobilization/Demobilization	$13,600,636	$1,459,574	$60,000	$60,000
Electrical Equipment	$6,770,000	$1,935,000	$1,935,000	$1,935,000
Permanent Fan	$306,000	$306,000	$306,000	$306,000
Dry Building	$760,000	$760,000	$760,000	$760,000
Office Building	$590,000	$590,000	$590,000	$590,000
Lateral Development	$2,256,616	$4,378,731		
Conveyor Belt		$1,661,000	$304,000	$304,000
Shafts/Ramps/Tunnels	$32,699,098	12,144,693	$3,987,930	$368,093
Earthmoving			$7,161,000	$2,700,900
Daily Indirects	8,457,297$	$5,077,687		
Contingency (10%-TMCC; 25% Marston)	$6,543,965	$2,831,268	$3,775,983	$1,755,998
Total	**$71,983,612**	**$31,143,953**	**$18,879,913**	**$8,779,991**

The shaft option evaluated by TMCC included two 20-foot diameter shafts in the center of the ore body 650 feet deep. The centralized location provides easy access for potential expansion of the mine to the east or north. Each shaft would be equipped with a hoisting system, one shaft would be used for production and the other would be a service shaft. TMCC estimated the construction of a shaft complex at $71,983,000 with a completion time of 1,079 calendar days.

To reduce the timeline and costs, Orvana asked TMCC to review an underground ramp option. TMCC proposed using a drill and blast operation to develop a 14-foot high by 16-foot wide slope at a 10 percent grade into the mine at a depth of 200 feet. Total ramp length was expected to be 2,500 feet. A ventilation raise with a vertical conveyor was included in this estimate. Total cost of the ramp option was $31,143,953 with a completion time of 742 calendar days.

Due to the relatively shallow depth of overburden along the south and southeast subcrop of the mineralized zone, Marston evaluated the option of mine access via box cut. Marston's initial design intercepted the Copper Bearing Sequence (which is the ore zone) at a depth of 104 feet. In the most current design, the box cut depth is 116 feet.

After the foregoing analyses were completed, the decision was made by Orvana that the development of the mine will be accomplished by accessing the ore horizon via a mine entrance ("box cut") and portal system which has been deemed the optimal method of entry. There will be a minimum of three portal entries, one for men and equipment, one for a conveyor haulage system for ore, and one being a ventilation portal. A minimum of two

entrances are required to comply with MSHA regulations to provide secondary means of egress for safety reasons.

The portals will be driven into the mine in the ore horizon, which basically eliminates the need to mine any waste. The ore dips to the north between 7 degrees and 12 degrees. The mine plan requires that the development drifts be driven down dip in a northerly direction, and also to the east for future mining of the Section 6 area. Current estimates are that it will require a minimum of two years to develop the deepest portion of the mine, at which time production will be done along strike to the east and west. The mine plan contemplates a systematic room and pillar mine design over the entire ore horizon using drill and blast extraction methods. This will allow for the most effective extraction of the resource, resulting in mining of +70% of the reserves.

The configuration of the geologic formations within the Copperwood project limits the location of the proposed box cut (Figure 3-1). The box cut needs to be located where the ore body is closest to the land surface to minimize the depth of the box cut. The ore body slopes from southeast to northwest, with the ore body closest to the surface in the area of the proposed box cut. The box cut must also be located to be in proximity to the mill site due to the transport of ore from the mine by conveyor to the mill site. The location of the Tailings Disposal Facility ("TDF"), which takes up a large area, also influences the location of these facilities. The location chosen for the mine entrance is between the Unnamed Creek and the West Branch Namebinag Creek, providing access to the center of the ore body while avoiding impacts to Namebinag Creek and also avoiding the historic test mine workings on the site.

Three box cut options were evaluated. The first option was an open box cut and was based on initial discussions with geotechnical experts from the region. The experts' observations indicated that the over-consolidated clays comprising the overburden would remain stable at high angles of repose after excavation. As such, a box cut was designed to provide a 150-foot by 200-foot staging area at the base of the slope with sufficient room for a sump, fan and any other equipment. Batter angles on the box cut are 60º with 20-foot safety benches every 30 feet along the high wall and sides, for an effective batter angle of 45º. Slope access would be developed on an 8% grade. The volume of material that would need to be removed for the box cut is about 230,000 cubic yards. The excavation would provide three entries into the mine including an air intake, an air return and an entry for the belt conveyor. Personnel and equipment would travel in either the belt or air intake entries.

The fourth side of the box cut is an inclined access ramp that will be constructed through the glacial overburden at a 10% decline from the ground surface for about 1,000 feet before engaging the ore body in the box cut. This method allows efficient access to the ore body with the least amount of waste rock.

The underground mine entrance excavation will impact approximately 1.39 acres of wetlands.

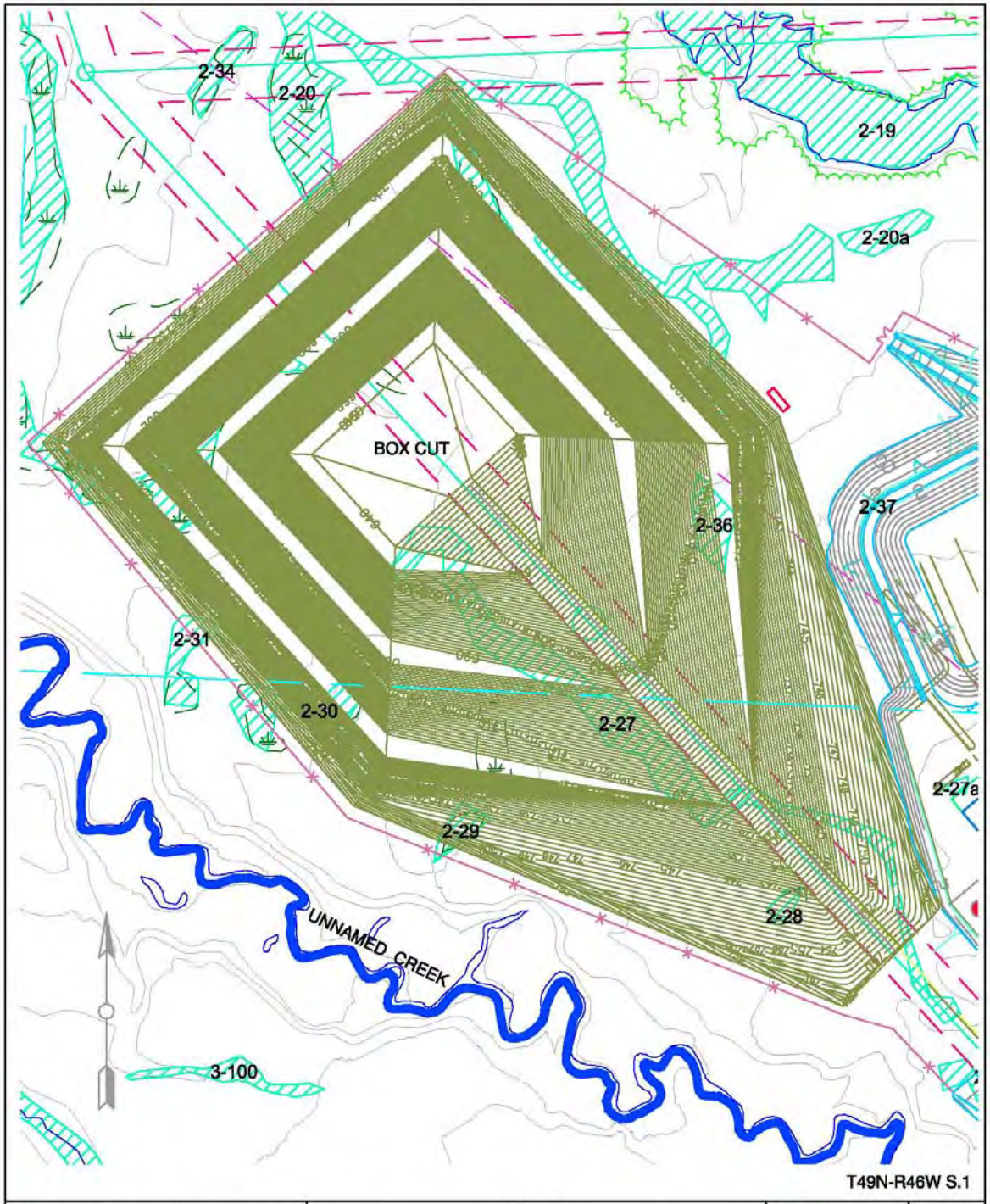

2-34
2-20
2-19
2-20a
BOX CUT
2-37
2-36
2-31
2-30
2-27
2-27a
2-29
2-28
UNNAMED CREEK
3-100
T49N-R46W S.1
COLEMAN ENGINEERING COMPANY
BOX CUT
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN
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FIGURE
3-1
I:\JOB FILES\CAD Projects\CAD12100 Orvana\Alt Analysis\Figure 3-1.dwg

4.0 Construction of the Mill Site

The “mill” referred to in this application for permit is the processing site for the mine and is comprised of the following 13 facilities (Figure 4-1):

- Administration/Engineering
- Core Storage
- Laboratory
- Mine Office/Change Room
- Diesel Station
- Maintenance Shops/Plant Offices
- Warehouse/Offices
- Mill Feed Stockpile Building
- Mill Building (includes grinding, flotation, MCC room, reagent handling)
- Tailings Thickener/Flocculent Area
- Water Treatment Plant
- Copper Concentrate Thickener
- Copper Concentrate/Truck Wash Building

The mill is proposed in a location as near as possible to the mine entrance to minimize wetland impacts and concentrate the development of the 13 facilities in a single area (Figure 4-1). The mill will be constructed over areas underlain by a rock formation known as Copper Harbor Conglomerate, not a part of the existing copper ore body within the rock formation known as Nonesuch Shale. It is important to not locate the mill site over the Nonesuch Shale due to mine safety concerns about having underground mine workings beneath the mill site due to the weight of the facilities, vibrations, etc. The ore body is closest to the ground surface in the vicinity of the mill site, exacerbating the safety concerns if the mill were to be located over the Nonesuch Shale. Ore will be transported out of the mine to the mill by conveyor; therefore locating the mill as close as possible to the mine entrance is important.

No other ore processing facilities currently operate in the local area. The White Pine Mine, approximately 27 miles east of the Copperwood site, was closed in the mid-1990s, and no ore processing capabilities remain at this facility. As a result, an on-site ore processing facility is a necessity for the Copperwood Project.

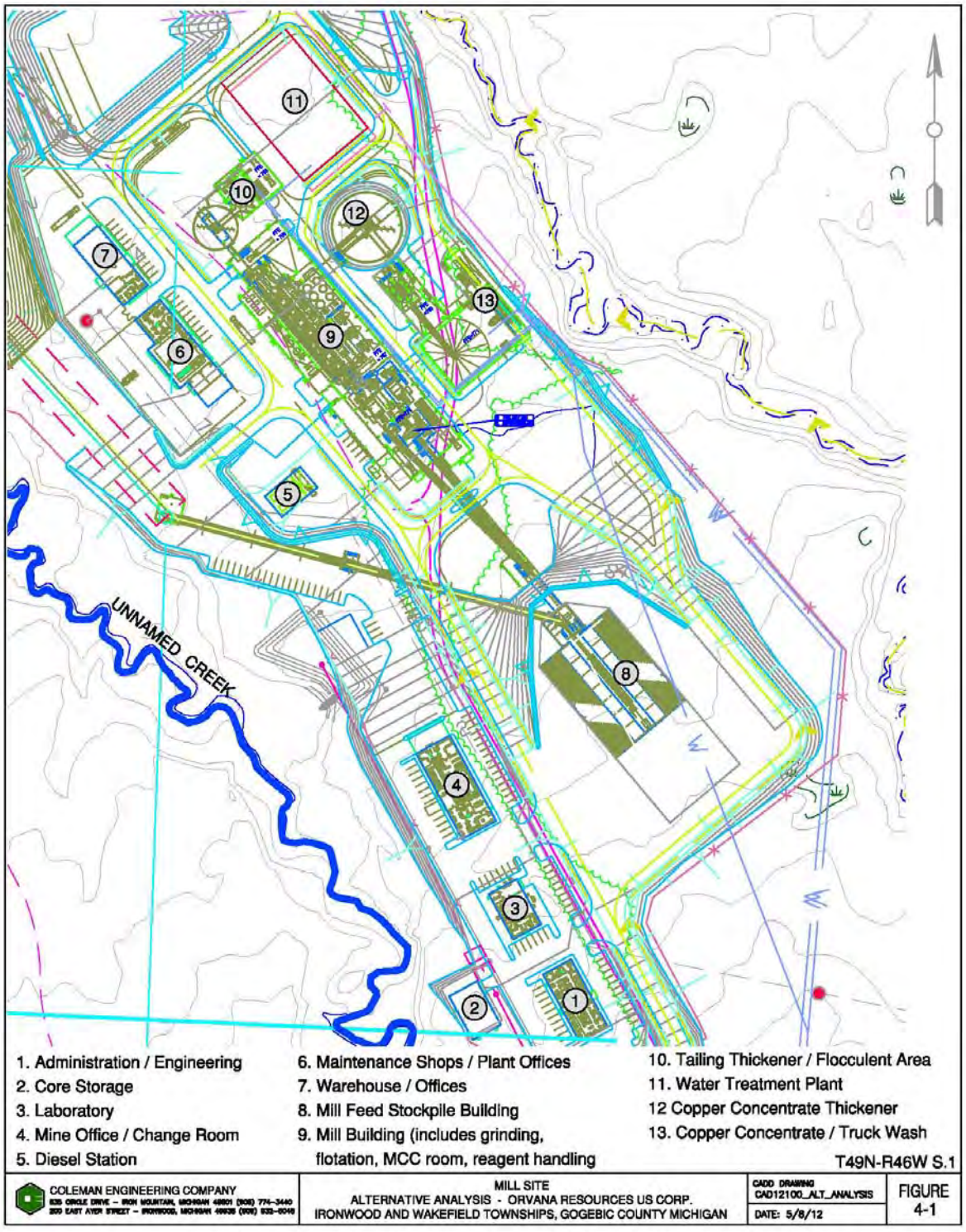
UNNAMED CREEK
1. Administration / Engineering
2. Core Storage
3. Laboratory
4. Mine Office / Change Room
5. Diesel Station
6. Maintenance Shops / Plant Offices
7. Warehouse / Offices
8. Mill Feed Stockpile Building
9. Mill Building (includes grinding, flotation, MCC room, reagent handling
10. Tailing Thickener / Flocculent Area
11. Water Treatment Plant
12 Copper Concentrate Thickener
13. Copper Concentrate / Truck Wash
T49N-R46W S.1
COLEMAN ENGINEERING COMPANY
MILL SITE
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN
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FIGURE 4-1
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The mill site includes a wastewater treatment plant (WWTP). Wastewater from mine dewatering, tailings, and the mill site will be stored in the TDF prior to treatment in the WWTP. From the TDF a decant basin sump system will collect water that that will either be treated in the WWTP (0 – 350 gpm) or recycled through the process mill (0 – 1089 gpm). Excess water that is not reclaimed for the process mill will be discharged from the WWTP through the outfall to the West Branch Namebinag Creek at an estimated maximum discharge rate of 350 gpm. The WWTP will include sedimentation of particulates, pH adjustment, microfiltration, adsorption on granular activated carbon, and membrane filtration by reverse osmosis and ion exchange. When issued, the MDEQ NPDES permit will specify effluent limits to be met by the discharge from the plant to West Branch Namebinag Creek.

The milling, processing, and concentrating process that will occur in the mill will result in a concentrate containing approximately 25% copper, which is the final on-site product. This final product will then be shipped to an off-site facility for further processing, i.e. smelting. No smelting will be done at the site.

The construction of the mill site will result in impacts to approximately 2.27 acres of wetlands.

5.0 Tailings Disposal Facility (TDF)

The waste product of the milling process is commonly called tailings. The host mineral for the copper is chalcocite. To liberate the copper from chalcolite, it has been determined that the optimal method will be as described below.

1. The processing facility will receive Run of Mine Ore (ROM) that will be minus 8-inch material. The current flow diagram of the processing facility utilizes a semi-autogenous grinding (SAG) mill to process the ore to a P80 of 300 micron size.

2. The material from the SAG mill then passes through a Ball Mill to grind the material to a P80 of 63 micron size.

3. The slurry will then be processed through a series of cyclones to separate material to less than 50 micron with the oversize being recirculated back to the ball mill.

4. This material will then be processed through a regrind mill to achieve a size of P80 20 microns, which is considered the optimal size to separate out the copper from the host rock.

5. The slurry will then be processed through a series of floatation and cleaner cells to separate out the copper and the host rock. The copper will be in concentrate, which is the final sellable product of the processing facility. The waste rock will

be slurry of comprised of 79% process water and 21% solids with a size P80 less than 20 microns.

Based on current design criteria, the tailings will require a large area to enable the water to separate from the solids which is normally termed consolidation. Due to the fine nature of the tailings, the current consolidation model indicates that the solids will stay in suspension for a long period of time and as a result will need a larger area of deposition to allow for this separation. The separation of water and solids will be accelerated as the tailings pond increases in depth. The proposal is to construct a TDF to dispose of 100% of the tailings that will be generated during the life of mine, which will allow for mining of the 30.3M tons of ore.

The volume of tailings to be produced from the milling operation is large and will be determined mainly by the ore volume removed from the mine. This application for permit proposes a TDF to be constructed on-site as the most feasible and prudent tailings disposal method. The following alternatives for tailings disposal considered were evaluated (Figure 5-1a and 5-1b):

- Alternative 1: Underground tailings disposal as a paste or concrete/paste mixture;
- Alternative 2: Disposal at the former White Pine Mine – South Tailings Disposal Area;
- Alternative 3: On-site TDF over mine;
- Alternative 4: On-site TDF in portions of Sections 6, 7 and 8, with a 140-foot dike;
- Alternative 5 (the proposed Alternative): On-site TDF in portions of Sections 6, 7 and 8, with a 116-foot high dike;
- Alternative 6: On-site TDF in Section 7 with 250-foot high dike;
- Alternative 7: On-site TDF in Section 7 with 175-foot high dike;
- Alternative 8: On-site TDF in Sections 6 and 7 with 140-foot high dike;
- Alternatives 9A through 9E: Off-site TDF options south of the proposed TDF location in T49N-R46W, Sections 12, 13, 24, 25, and 36, respectively.

Each on-site option for the TDF design included an underdrain system to promote tailings dewatering. Dewatering increases tailings density; this reduces the tailings volume and hence reduces the size of the required TDF footprint. The water from the tailings dewatering will be recycled in the mill and excess water that is not reclaimed for the process mill will be treated in the WWTP before being discharged to surface water.

The TDF alternative evaluation conducted by Orvana generally included the following considerations (not necessarily in order of importance):

- Wetland and higher quality stream avoidance
- Proximity to mine/mill complex and avoidance of sites over underground mining area
- Tailings volume for disposal and dike size required and construction costs
- Avoiding key ecological receptors and visual impacts and the North Country Trail
- Proximity to Lake Superior
- Safety, topography, low permeability soils, depth to bedrock
- Optimal geological, geotechnical, and hydrogeological conditions

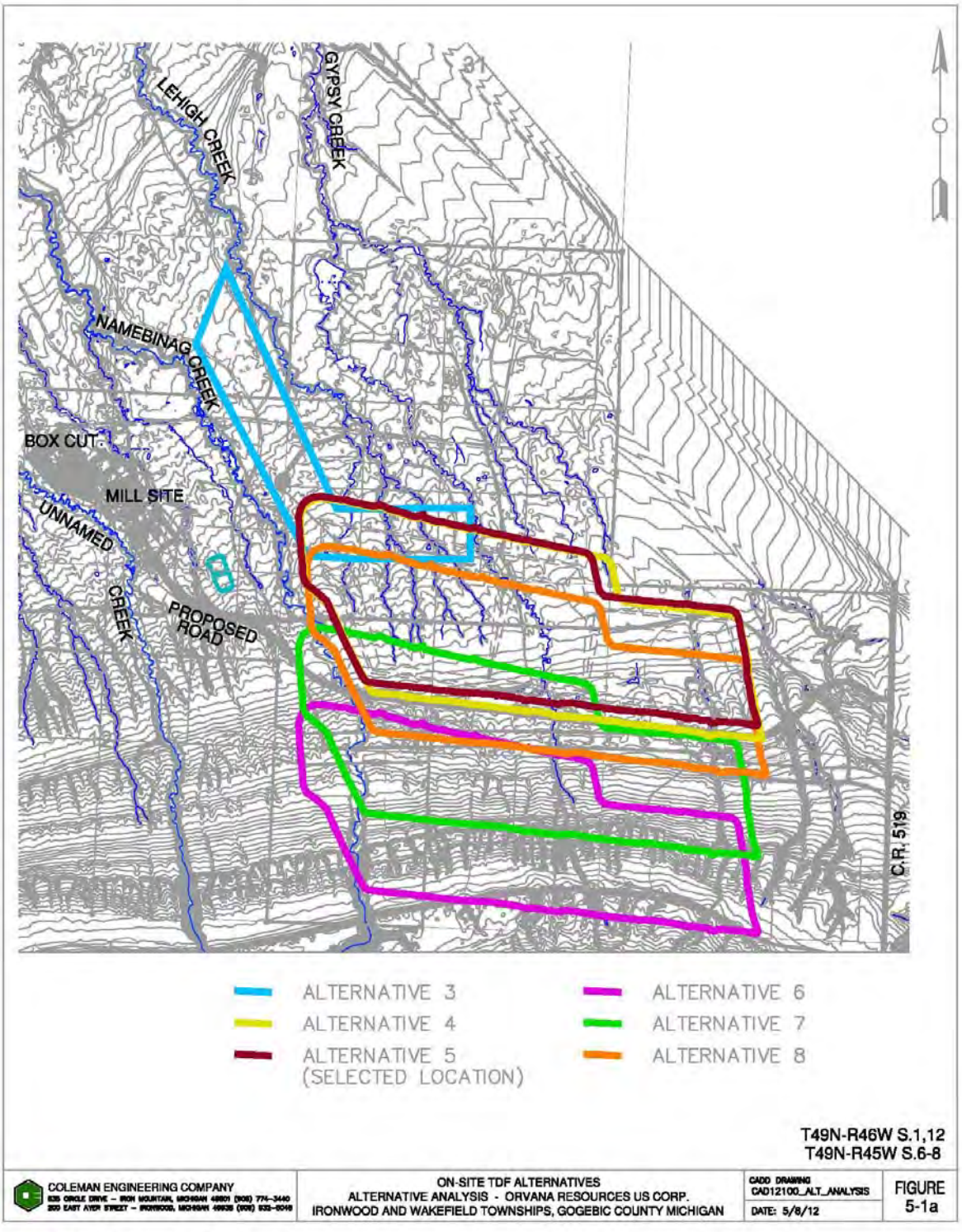
LEHIGH CREEK
GYPSY CREEK
NAMEBINAG CREEK
BOX CUT
MILL SITE
UNNAMED CREEK
PROPOSED ROAD
C.R. 519
ALTERNATIVE 3
ALTERNATIVE 4
ALTERNATIVE 5
(SELECTED LOCATION)
ALTERNATIVE 6
ALTERNATIVE 7
ALTERNATIVE 8
T49N-R46W S.1,12
T49N-R45W S.6-8
COLEMAN ENGINEERING COMPANY
ON-SITE TDF ALTERNATIVES
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN
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FIGURE
5-1a
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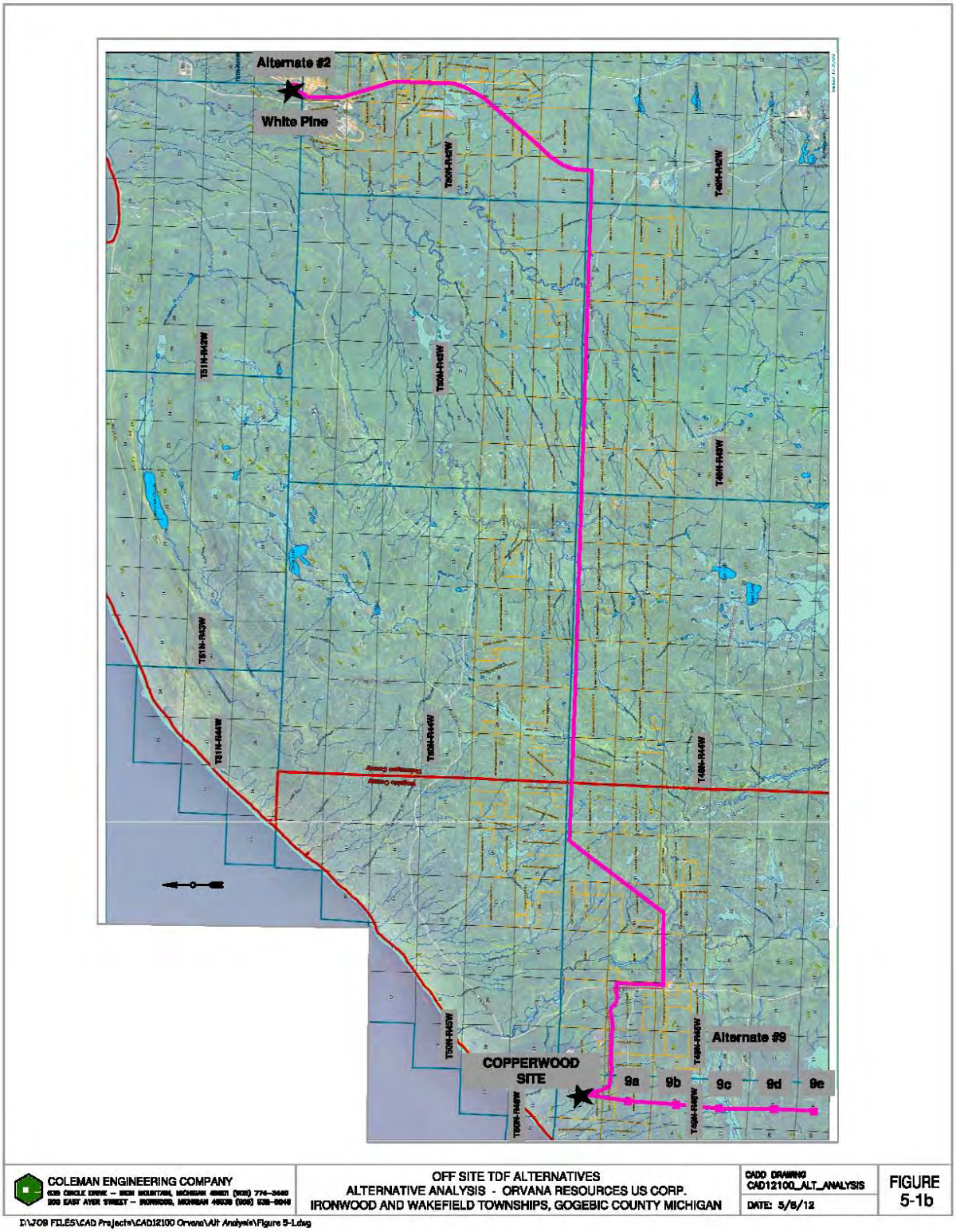

COLEMAN ENGINEERING COMPANY
620 CIRCLE DRIVE – IRON MOUNTAIN, MICHIGAN 49801 (906) 774-2440
200 EAST AYER STREET – IRONWOOD, MICHIGAN 49938 (906) 932-5040

OFF SITE TDF ALTERNATIVES
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN

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FIGURE
5-1b

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5.1 Alternative 1: Underground Tailings Disposal as Paste or Concrete/Paste Mixture.

Alternatives to deal with the tailings disposal included returning the tails to the underground workings for final deposition. This is done in some instances as either slurry, pasted, or cemented paste fill. The current mine plan incorporates partial pillar recovery which could accommodate tailings disposal; however, this option is not deemed viable due to reasons provided in the following paragraphs.

The current mine plan contemplates a 13-year mine life mining a total of +30.3 M ton of ore. Essentially 25% of the total reserve tons will be mined during the first four years of mine development and production before any opportunity would exist to place tailings underground. Based on the current mine plan, the tons generated from development and mining for the first four years are shown in Table 5-1.

Table 5-1. Copperwood Planned Development: Tons per Year 1-4

Year→	**1**	**2**	**3**	**4**
Tons per year	530,000	1,700,000	2,625,000	2,625,000
Cumulative Tons	**530,000**	**2,230,000**	**4,855,000**	**7,480,000**

As a result of the mine plan, there will be no isolated areas to deposit tailings until the deepest portions of the mine are completely mined with no need for access into these areas. The option of depositing tailings at elevations higher than active working areas in the mine is not contemplated due to safety concerns. Tailings could be semi-fluid and could flow to other areas of the mine, which is a safety concern.

This mine plan is contingent on achieving the planned levels of advance. Since early stages of development require the advance of the drifts down dip, there is a risk of slower advance due to operating conditions that could result in lower productivity to include:

- Competency of newly hired employees while they build their skill sets
- Unexpected ground control issues
- Pumping requirements due to dust suppression requirements and unplanned rates of water inflow. Adequate sump and dewatering systems will have to be developed as the new entries are advanced. These requirements usually result in a slower rate of advance

The current plan allows for slower development advance since at any time mining could be done along strike. This would only be allowed if scheduled development advances could not be achieved. If the current plan is achieved, it will take a minimum of four years to mine sufficient area to allow for placing tailings underground. If there are delays

in advancing to the deepest portions of the mine, the option of putting tailings underground would be delayed.

If the geotechnical work done regarding pillar strengths and pillar stability confirms that lower working areas can be flooded, then the option of depositing tailings underground could be pursued; however, the risk of developing a mine without sufficient storage capacity for tailings would not be prudent. Only after mining has progressed to a point with substantial volumes of mined out areas could tailings be deposited underground in the lowest portions of the mine.

Furthermore, bulking the tailings would increase the tailings volume, so a permanent, albeit somewhat smaller, above-ground tailings disposal facility would still be required for tailings that could not be returned to the mine. "Bulking the tailings" refers to the addition of solidifying agents, such as cement or fly ash, being added to the tailings on at least a 1:1 ratio. This would double the volume of the tailings and, when considering that the tailings cannot be compressed to regain the density of the rock removed from the mine, only about 25% of the tailings removed from the mine could physically fit back into the mine workings.

In summary, there may be an opportunity to evaluate the placing of tailings underground at some point in the future; however there will be a significant amount of tailings generated before this option could even be considered.

In addition, Alternative 1 would require substantial above-ground tailings storage and some degree of above-ground permanent disposal would still be required. Due to the fact that only about 25% of the tailings could be returned to the mine workings as explained above, Stages 1 and 2 of the proposed TDF would still be required to store the excess tailings, and those stages of the TDF contain 39.75 acres of wetland. Thus, wetland impact would still be substantial with the implementation of Alternative 1 for underground placement of tailings in the mine workings.

5.2 Alternative 2: Disposal at the Former White Pine Mine South Tailings Disposal Area

Two options regarding use of the former White Pine Mine were considered. The first option consists of transporting raw (unprocessed) ore from the Copperwood site to the White Pine site if it had an operating processing mill and TDF developed on that site (Figure 5-2). Another option would be to process the ore at the Copperwood site and then pump the tailings to the White Pine facility. With these options, the most obvious issue is the distance and terrain between the two sites, which would pose significant construction and operating issues as well as cost, as described below. The White Pine Mine is approximately 27 miles east of the proposed Copperwood mine site, with rugged terrain and a significant elevation differential to cross. The Porcupine Mountains Wilderness State Park and the Ottawa National Forest are located between Copperwood and White Pine, so the shortest route between these locations would need to cross these public lands.


White Pine
COPPERWOOD SITE
T51N-R43W
T51N-R44W
T51N-R45W
T50N-R43W
T50N-R44W
T50N-R45W
T49N-R43W
T49N-R44W
T49N-R45W
COLEMAN ENGINEERING COMPANY
TDF ALTERNATIVE #2
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN
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FIGURE
5-2
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Transportation of raw ore from Copperwood to White Pine by truck would involve about 150 round trips daily by trucks passing through the Porcupine Mountains Wilderness State Park. Construction of a pipeline between Copperwood and White Pine for transport of the processed ore through the State Park and Ottawa National forest, involving many wetland and stream crossings, is not feasible or prudent. Transporting tailings slurry via a pipeline for that distance would require a significant volume of water and several pumping stations.

The former TDF at White Pine has been substantially decommissioned by removal of dikes when the clay was apparently used to cap the tailings inside the former dam during mine closure. A TDF would have to be reconstructed at the White Pine site. Due to the lack of feasibility of the TDF being located at White Pine, it has not been investigated further. For these reasons, the processing of Copperwood ore and disposal of tailings at the White Pine site are not feasible or prudent, and would likely have environmental impacts that are unacceptable. These impacts to off-site resources can be avoided by implementing the on-site ore processing and TDF. Due to the lack of feasibility of this alternative, the wetland impacts were not determined.

5.3 Alternative 3: On-site Tailings Disposal Facility over Mine

TDF Alternative 3 is located between Namebinag Creek and Lehigh Creek in Sections 1 and 6 (Figure 5-3). A geotechnical investigation was performed within the outline of this alternative, and conditions were found to be favorable for construction. The TDF as outlined for this location, however, is not large enough for the required volume of tailings.

The most important factor that weighs against Alternative 3 is locating a TDF over mine workings. The weight of the TDF over underground mine workings is a mine safety concern and, for this reason alone, is not prudent. Also considered is the close proximity of the TDF to Lake Superior, which also serves to make this TDF location not prudent. Alternative 3 is closest to Lake Superior of all the alternatives. Approximately 16.69 acres of wetlands and 3,877 linear feet of stream would be impacted by Alternative 3.

The costs were scoped in the Orvana Preliminary Economic Assessment (“PEA”) report and were determined to be $16.98M to construct in four stages, and $4.69M for closure costs for a total cost of $20.67M.

Alternative 3 is not feasible or prudent due to the TDF would be located above the mine workings and the closest proximity to Lake Superior.

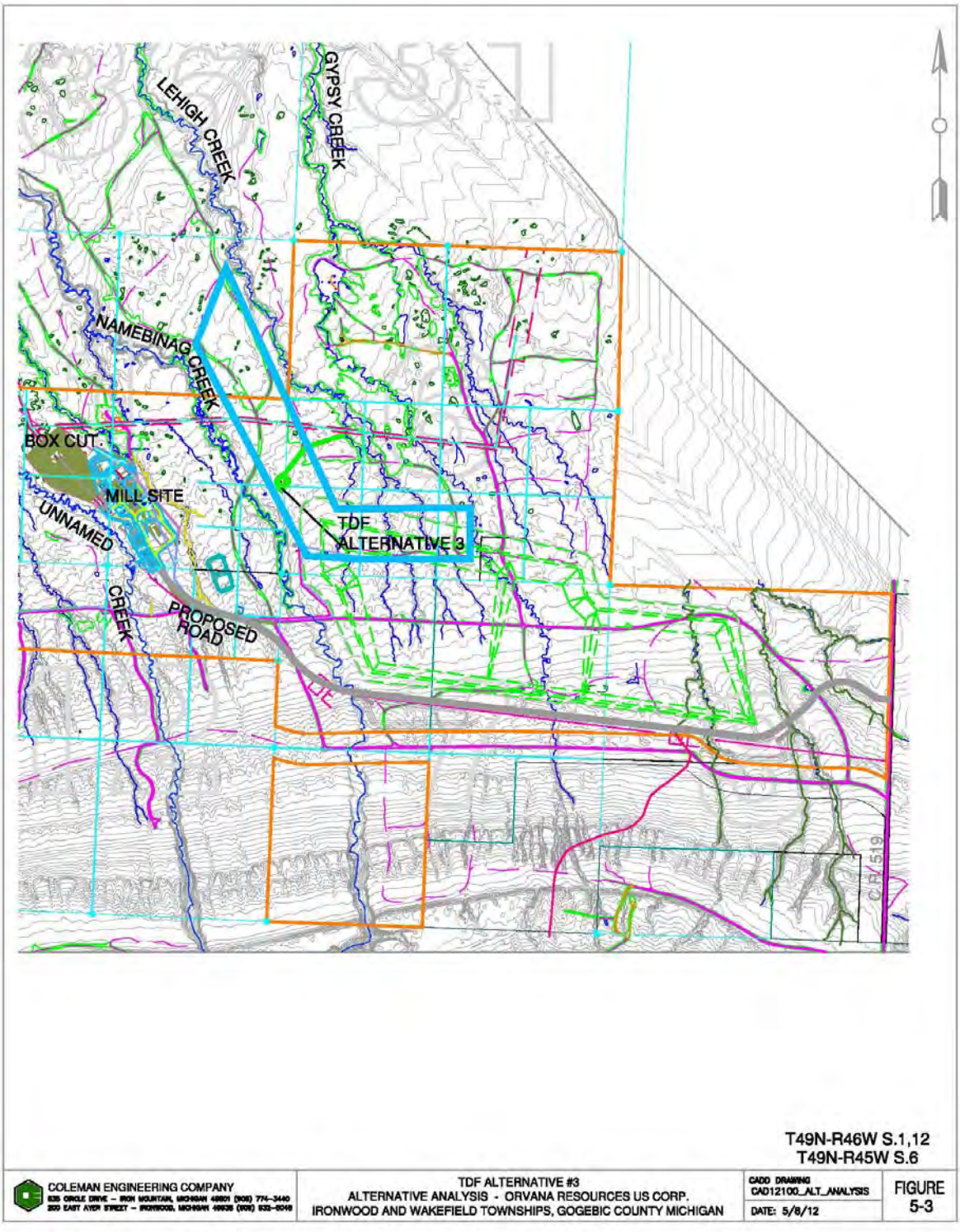
LEHIGH CREEK
GYPSY CREEK
NAMEBINAG CREEK
BOX CUT
MILL SITE
UNNAMED
CREEK
TDF
ALTERNATIVE 3
PROPOSED
ROAD
CR 519
T49N-R46W S.1,12
T49N-R45W S.6
COLEMAN ENGINEERING COMPANY
TDF ALTERNATIVE #3
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FIGURE
5-3
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5.4 Alternative 4: On-site Tailings Disposal Facility in Portions of Sections 6, 7, and 8 with 140-foot High Dike.

Alternative 4 was developed to contain the full volume of expected tailings from the mining operation. The TDF was placed entirely to the south of the mining area and is underlain by non-ore containing Copper Harbor Conglomerate formation (Figure 5-4). Therefore the TDF would not be located over mined areas. The TDF would be developed in five stages over the life of the project, with the ultimate configuration designed to store 30.32 million tons.

The TDF site is in an area of variable but generally quite deep, very low permeability clay. Tailings will be contained partially below grade in a basin excavated into the till and partially above grade behind a zoned earth fill dike constructed by the conventional downstream method. At full build out the dike will range in height from approximately 17 to 140 feet. The embankment has been designed as a water retention structure due to the soft and wet nature of the tailings to be stored, and the large size of the operational water pond (supernatant pond) that will be contained in the TDF above the tailings.

Alternative 4 was located to avoid impacts to Namebinag Creek and the East Branch Gipsy Creek. The ground at this location is relatively flat, thereby reducing the height of the required downstream dike. In addition, Alternative 4 is more than 1.5 miles at the closest point from Lake Superior. Geotechnical investigation results indicate that the subsurface conditions are favorable for placement at this location; i.e. there is approximately 65 feet of primarily clay soil underneath the proposed TDF site.

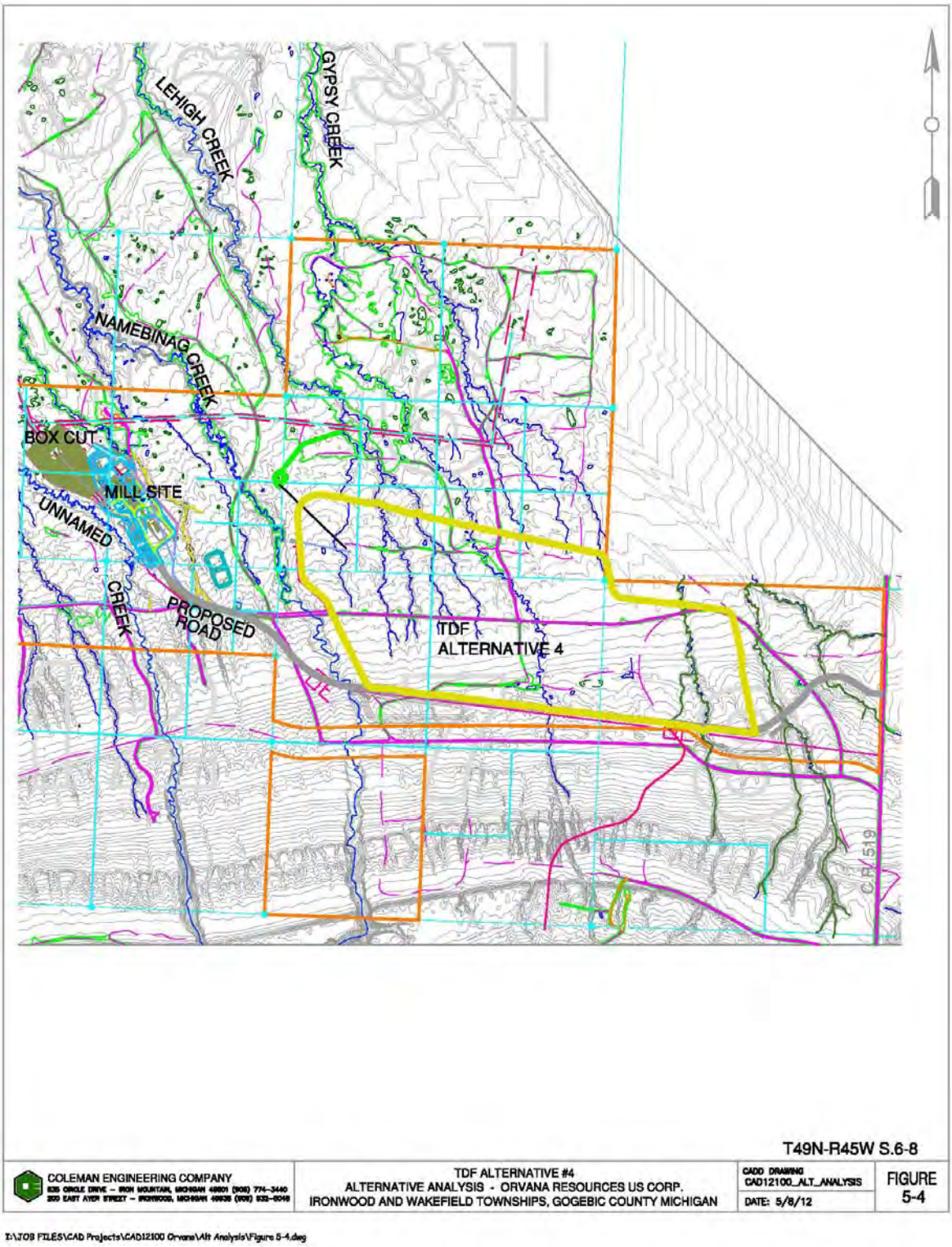
Showy orchis (*Galearis spectabilis)*, which is listed as a threatened plant species in the State of Michigan, has been found within the limits of the Alternative 4 TDF. During a 2011 survey, 23 plants were identified in communities #5 and #6. Prior to impacting this plant species, a permit is required from the Michigan Department of Natural Resources (MDNR) under Part 365 of NREPA (Endangered Species Protection). An application for the permit to relocate the 23 plants was submitted to MDNR on April 23, 2012.

Alternative 4 will impact approximately 51.84 acres of wetland and will impact 13,672 linear feet of the upper portions of several ephemeral streams with flow originating from spring snow melt and precipitation (i.e. no groundwater-fed base flow). The construction of Alternative 4 would require the excavation and placement of approximately 10 million cubic yards of earth to construct the dike.

5.4 Alternative 4, continued

The costs for Alternative 4 were detailed in the Project Feasibility Study ("PFS") report. These costs were determined to be $81.58M for construction and $23.09M for closure costs, for a total cost of $104.67M. The construction costs are primarily a function of the several million cubic yards of fill necessary for TDF dike construction. This material would need to be imported from an off-site location. Obtaining such fill (from an unknown source) could potentially impact regulated resources as well.

While Alternative 4 and the preferred alternative (Alternative 5) may have similar on-site regulated resource impacts since their footprints are essentially the same, the unknown impacts and costs of obtaining off-site fill for the TDF to "earth balance" rendered Alternative 4 to not be prudent.


LEHIGH CREEK
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MILL SITE
UNNAMED
CREEK
PROPOSED ROAD
TDF ALTERNATIVE 4
CR 519
T49N-R45W S.6-8
COLEMAN ENGINEERING COMPANY
TDF ALTERNATIVE #4
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN
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FIGURE 5-4
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5.5 Alternative 5: On-site Tailings Disposal Facility in Portions of Sections 6, 7, and 8 with 116-foot High Dike (Proposed/Preferred Alternative)

This preferred alternative, Alternative 5, was developed to contain the full volume of expected tailings from the mining operation. It is in the same vicinity as Alternative 4. The TDF was placed entirely to the south of the mining area and is underlain by non-ore containing Copper Harbor Conglomerate formation (Figure 5-5). Therefore the TDF would not be located over mined areas. This location also has a thick layer of natural clay till that will isolate the TDF from groundwater. The drain leachate collection system under the TDF will reduce head pressure in the TDF and help to consolidate the tailings.

Excess water from the TDF will discharge to the decant basin where it will be pumped back to the mill. The decant basin has a sump and an emergency overflow basin available for water storage in the case of a power outage. The emergency overflow basin will have a riprap spillway that will outlet decant water to Lehigh Creek if emergency generator at the decant sump fails and power can't be restored prior to the basin filling up.

Alternative 5 was located to avoid impacts to Namebinag Creek and the East Branch Gipsy Creek. The ground at this location is relatively flat, thereby reducing the height of the required downstream dike. In addition, Alternative 5 is more than 1.5 miles at the closest point from Lake Superior. For the most part, the TDF and mill site will not be visible from the Lake of the Clouds overlook at Porcupine Mountains Wilderness State Park due to the low profile of the buildings and the tree cover. A small clearing, however, may be visible from this overlook, and the tops of the TDF dikes may be visible above the tops of trees, although somewhat less visible than Alternative 4 due to a dike height difference of approximately 24 feet. Because the dikes will be vegetated, however, there should be minimal impact to the view shed.

Geotechnical investigation results indicate that the subsurface conditions are favorable for placement at this location; i.e. there are approximately 100 feet of primarily clay soil underneath the proposed TDF site. However, Alternative 5 would impact the upper portions of several ephemeral streams with flow originating from spring snow melt and precipitation (i.e. no groundwater-fed base flow).

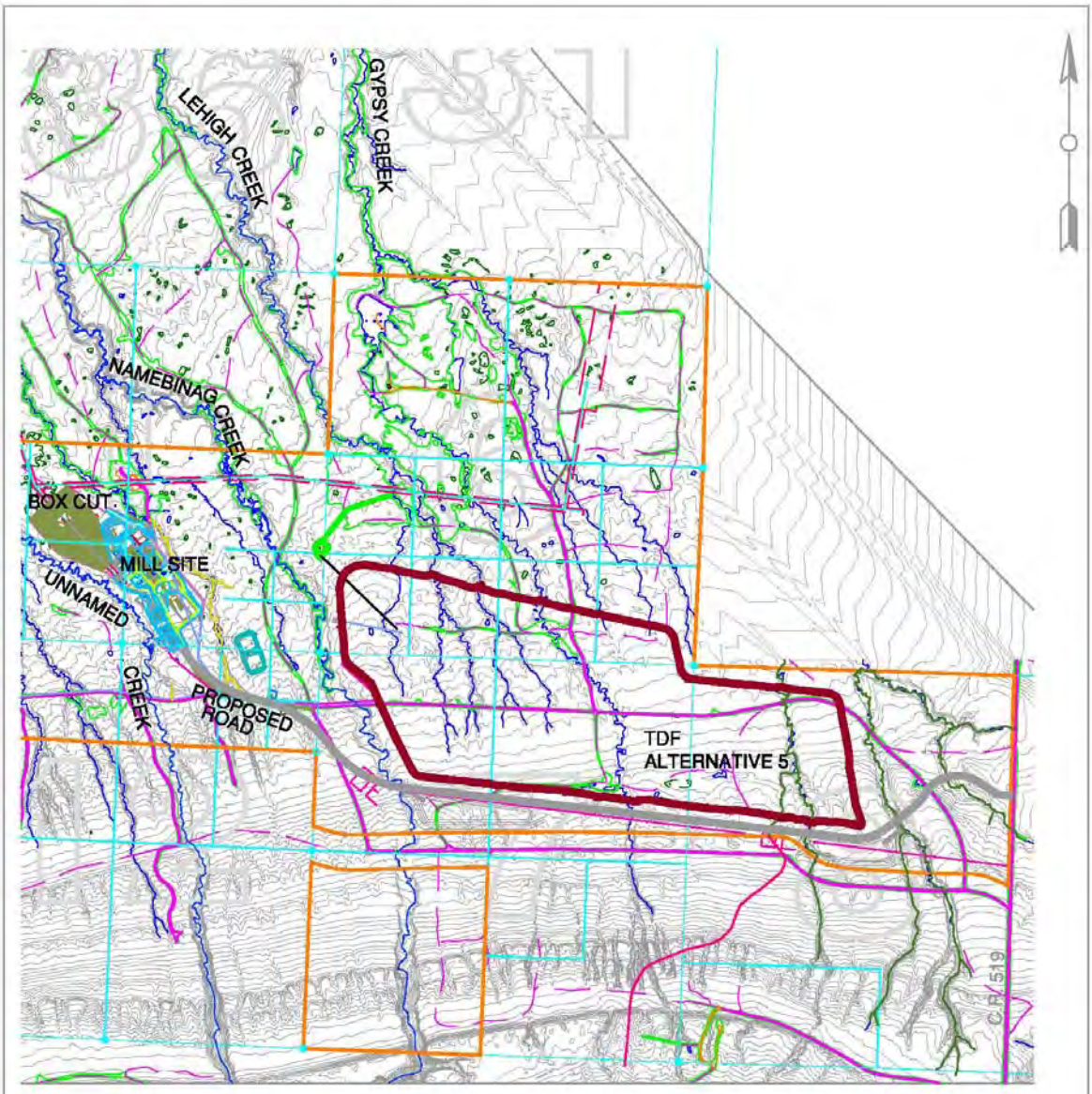
Showy orchis (*Galearis spectabilis)*, which is listed as a threatened plant species in the State of Michigan, has been found within the limits of the proposed TDF. During a 2011 survey, 23 plants were identified in communities #5 and #6. Prior to impacting this plant species, a permit is required from the Michigan Department of Natural Resources (MDNR) under Part 365 of NREPA (Endangered Species Protection). An application for the permit to relocate the 23 plants was submitted to MDNR on April 23, 2012.

5.5 Alternative 5, continued

Alternative 5 will impact approximately 51.84 acres of wetland and will result in the removal of approximately 13,672 linear feet of ephemeral stream channel. It will require the excavation and placement of approximately 10 million cubic yards of earth to construct the dike. Alternative 5 has a zero soil balance (i.e. all material for the TDF dike will be obtained from within the TDF). Alternative 5 also includes a decant basin sump, from which water that is decanted from the TDF is pumped back to the mill.

The costs were detailed in the Bankable Feasibility Study ("BFS") for three stages of construction and are $81.45M for construction and $20.82M for closure costs, for a total cost of $102.27M.

Alternative 5 for the TDF is feasible and prudent when compared to the other alternatives for the TDF. Although Alternative 5 is not the least damaging alternative, it is the most practicable alternative when all aspects of the project are considered, including cost, availability, and mine safety.



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635 CIRCLE DRIVE – IRON MOUNTAIN, MICHIGAN 49801 (906) 774-3440
320 EAST AYER STREET – IRONWOOD, MICHIGAN 49938 (906) 932-5048

TDF ALTERNATIVE #5
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FIGURE 5-5

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5.6 Alternative 6: On-site Tailings Disposal Facility in Section 7 with 250-foot High Dike

Alternative 6 (Figure 5-6) is located south of Alternative 5 and is the southernmost of all on-site alternatives. Alternative 6 would require relocation of the North Country National Scenic Trail ("North Country Trail"), which occupies an easement owned by the U.S. Forest Service. Bedrock is as close as 10 feet to the surface in this area with some bedrock outcrops in streambeds. Excavation to create tailings storage volume would be substantially more difficult and expensive for Alternative 6 than for Alternative 5 due to the amount of the rock cut that would be required.

There is steeper topography in the Alternative 6 location, which reduces the storage volume available in the TDF, and would also mean the dikes would need to be taller and/or the footprint of the TDF larger than Alternative 5. Alternative 6 requires a dike approximately 250 feet high to contain the volume of tailings. A 250-foot high dike at a higher elevation means the TDF would be much more visible from a distance than the other alternatives, including the overlook at Lake of the Clouds in the Porcupine Mountains Wilderness State Park as well as from Lake Superior.

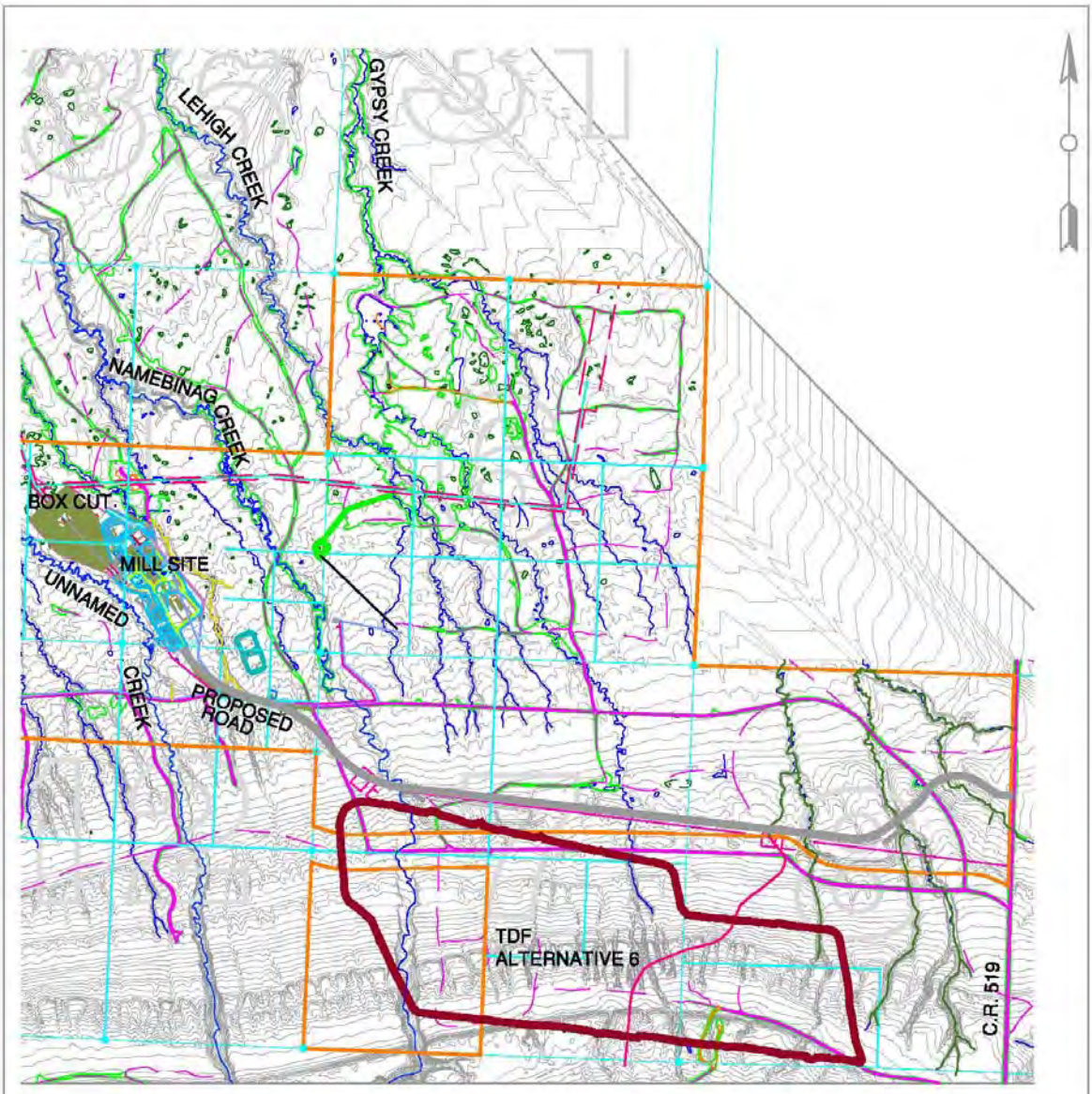
Construction of this dike for Alternative 6 would require approximately 32.5 million cubic yards of material, more than three times the volume required for Alternative 5. A major issue with Alternative 6 is that most of the material to construct the dikes would have to come from some other location; off-site, on-site, or a combination of both due to bedrock being close to the surface. The soil to construct the dike must meet the specifications for the dike (clay). The size of the borrow pit to obtain the 32.5 million cubic yards of clay from one location would be about 31 feet deep and cover about 640 acres (one square mile). The borrow pit would likely have impacts to regulated resources.

Using a conservative cost estimate of $5 per cubic yard for clay to be transported from an off-site borrow area to the Alternative 6 location, the 32.5 million cubic yards of material would add an estimated $150M to the construction cost. This added cost makes Alternative 6 not prudent.

Groundwater is located on the upper surface of the bedrock in most areas investigated during the mine studies. Alternative 6 would intercept the groundwater on the bedrock and would have to be run through the WWTP because it has high levels of brine. The infusion of groundwater into the TDF is not desirable due to the treatment needed. If this alternative were to be implemented, a slurry wall would have to be constructed south of the TDF to intercept groundwater. Rock cut would be required to key the slurry wall in below the surface of the bedrock where groundwater is located. Although costs have not been determined, it is known that the slurry wall construction would add substantially to the cost of Alternative 6.

5.6 Alternative 6, continued

Alternative 6 would impact approximately 8 acres of wetlands and 4,025 linear feet of stream. Alternative 6 is not feasible due to the height of the proposed dike and construction costs. It is not prudent due to the potential for groundwater entering the TDF, which would add to wastewater processing costs and would result in visual impacts from the Porcupine Mountains Wilderness State Park and Lake Superior.


LEHIGH CREEK
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BOX CUT
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UNNAMED
CREEK
PROPOSED ROAD
TDF
ALTERNATIVE 6
C.R. 519
T49N-R46W S.1,12
T49N-R45W S.6-8
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TDF ALTERNATIVE #6
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
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5.7 Alternative 7: On-site Tailings Disposal Facility in Section 7 with 175-foot High Dike

Alternative 7 is also located south of Alternative 5, the proposed alternative, but not as far south as Alternative 6 (Figure 5-7). Bedrock is within approximately 10 feet of the surface; excavation to create tailings storage volume would be more difficult and expensive than for Alternative 5. The steeper topography in this area reduces the storage volume available, which also means the dikes must be taller and/or the footprint larger than Alternative 5. This alternative requires a dike about 175 feet high to contain the volume of tailings. As with Alternative 6, a 175-foot high dike at a higher elevation means the TDF would be much more visible from a distance than the other alternatives (except for Alternative 6) including the overlook at Lake of the Clouds in the Porcupine Mountains Wilderness State Park as well as from Lake Superior.

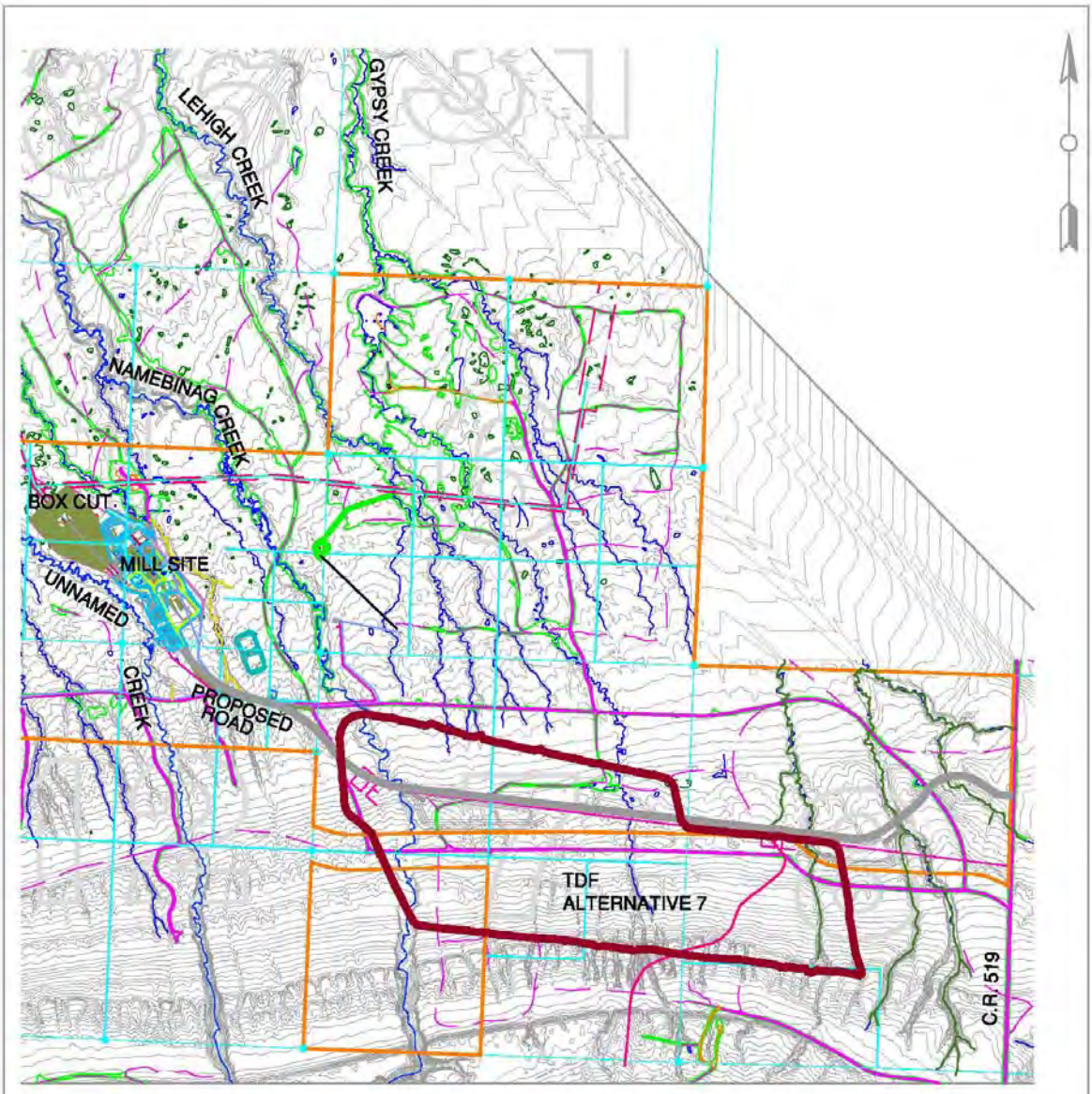
Construction of the dike for this alternative would require approximately 20 million cubic yards of material, about two times the volume required for Alternative 5. The shallow depth to bedrock and lack of a substantial clay soil in this area would increase the cost of construction compared to Alternative 5. Groundwater is present at the interface between the overburden and bedrock, so breaching this zone will create a water issue for the TDF.

Using a conservative cost estimate of $5 per cubic yard for clay to be transported from an off-site borrow area to the Alternative 7 location, the 20 million cubic yards of material would add an estimated $100M to the construction cost. This added cost makes Alternative 7 not prudent.

Alternative 7 would require relocation of the North Country Trail and would impact approximately 26 acres of wetlands and 7,374 linear feet of stream.

Alternative 7 is not feasible due to the presence of bedrock within 10 feet of the ground surface within the perimeter of the TDF and the height of the proposed dike that would have visual impacts from Porcupine Mountains Wilderness State Park and Lake Superior. As with Alternative 6, if this alternative were to be implemented, a slurry wall would have to be constructed south of the TDF to intercept groundwater. Rock cut would be required to key the slurry wall in below the surface of the bedrock where groundwater is located. Although costs have not been determined, it is known that the slurry wall construction would add substantially to the cost of Alternative 7.

Alternative 7 is not prudent due to the high cost compared to Alternative 5, specifically for the $100M additional cost for trucking clay to build the TDF dike.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MILL SITE
UNNAMED
CREEK
PROPOSED ROAD
TDF
ALTERNATIVE 7
C.R. 519
T49N-R45W S.6-8
COLEMAN ENGINEERING COMPANY
TDF ALTERNATIVE #7
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN
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5.8 Alternative 8: On-site TDF in Sections 6 and 7 with 140-foot High Dike

Alternative 8 is also located south of Alternative 5, but not as far south as Alternative 6 or Alternative 7. Alternative 8 requires a 140-foot high dike to contain the volume of tailings, approximately the same height as Alternative 5. The higher elevation of Alternative 8 on the landscape means the TDF would be more visible from a distance than Alternative 5, including the overlook at Lake of the Clouds in the Porcupine Mountains Wilderness State Park and from Lake Superior, but less visible than Alternative 6 or Alternative 7.

Bedrock is within 12 feet of the ground surface at the location of Alternative 8. As such, material for dike construction would have to come from off-site (i.e. no excavation to borrow material from within the TDF for dike construction is feasible due to the proximity of bedrock to the surface). The dike construction would require approximately 13 million cubic yards of material. Using a conservative cost estimate of $5 per cubic yard for clay to be transported from an off-site borrow area to the Alternative 8 location, the 13 million cubic yards of material would add an estimated $65M to the construction cost.

Alternative 8 would require relocating the North Country Trail and would impact approximately 42 acres of wetlands and 16,530 linear feet of stream. Wetland impacts are 7.79 acres less than Alternative 5, but the additional $65M in dike material costs make this alternative not prudent.

5.9 Alternative 9: Off-site TDF options from one to five miles south of the Mine, in T49N-R46W, Sections 12, 13, 24, 25, and 36, respectively.

Other off-site locations were investigated at distances up to five miles from the mine site (Figure 5-1b). The Presque Isle River is located approximately two miles east and the Black River approximately two miles west. Both rivers have portions designated as National Wild and Scenic Rivers, thereby eliminating locating the TDF in those directions from the Copperwood Project. Locations to the south of the project are available that could potentially accommodate a tailings facility of the required capacity; however, the watersheds of the Black River and Presque Isle River also begin at approximately one mile to the south. Both of these rivers are popular recreation destinations with a network of trails, waterfalls, day use areas and campgrounds and locating the TDF in the headwaters of these rivers is not prudent.

Scoping level costs for tailings and reclaim water pumping systems were developed as part of the BFS in one mile increments to the south of the proposed TDF location (Table 5-2). The base case (the proposed TDF location) has estimated costs of $2.7M for construction of the tailings and return water pipeline and pumping systems. Each mile further south of the proposed facility adds approximately $1M to these installation costs.

There is an elevation increase of approximately 400 feet moving to the south and construction of pipelines would involve crossing a bluff with near-surface bedrock in the area, creating high cost and construction issues.

Orvana requested K D Engineering (KDE) to review and submit a scoping level study for tailings and reclaim water pumping system for one on-site and five off-site alternative TDF sites. The costs for these options that were reviewed by KDE are summarized in Table 5-2.

Table 5-2. Costs for Pumping Associated with One On-Site and Five Off-Site TDF Locations.

TDF Alternatives	Dam Site Location From Plant site (miles)	Tailings Pumping System Cost ($)	Reclaim Water Pumping System Cost ($)	Total Cost ($)
Alternative 5 (Proposed)	1	2,120,000	590,000	2,710,000
Alternative 9a	2	3,000,000	760,000	3,760,000
Alternative 9b	3	3,830,000	960,000	4,790,000
Alternative 9c	4	4,600,000	1,150,000	5,750,000
Alternative 9d	5	5,440,000	1,360,000	6,800,000
Alternative 9e	6	6,100,000	1,510,000	7,610,000

Locating the TDF off-site is not prudent because the construction and operation of two pipelines adds substantial costs to the project, as identified in Table 5-2. Added to the cost of the pipelines would be bedrock construction and vertical grade issues.

Operating costs for pumping from two miles for Option 2 and six miles for Option 6, including pipeline maintenance, would add to the costs in Table 5-2. In addition, the amount of tailings and water in the pipeline must be accounted for if a pipe breaks or some other malfunction occurs. When a tailings pipeline has to be shut down for any reason, the tailings in the line have to be discharged at low points along the line into drain ponds. If only the water in the line is drained out, the tailings will be deposited in the line and the line may have to be dismantled to remove the tailings prior to start of pumping. Depending on the length of pipe that is being drained, a sizeable drain pond may be required and could affect regulated resources. The fresh water return line from the TDF to the mill would also have to be drained into drain ponds if the line had to be maintained. These are all major considerations for locating a TDF two to six miles from the mill.

Due to the lack of feasibility of these off-site alternatives, wetland and stream impacts have not been evaluated for off-site alternatives 9a through 9e.

5.10 Summary of TDF Alternatives

Alternative 5 was selected as the only feasible and prudent (practicable) alternative and is the therefore the preferred and proposed alternative. Due to the factors discussed in the TDF analysis, the current mine plan incorporates the use of a TDF for the deposition

of 100% of the tailings produced during the mine life. The analysis of alternatives was also completed by Orvana due to legal requirements of the Canadian Government (Orvana is Canadian corporation), even if the mine (as in this case) is in another country. As part of the feasibility study reporting completed for the Canadian National Instrument (NI) 43-101 requirements for Canadian companies, Qualified Persons (QPs) must agree to the most prudent alternatives regarding all aspects of the project. .

6.0 Access Road

This section evaluates the road access to the Copperwood Project; both the Gogebic County road access and the mine access road from the Gogebic County road.

6.1 County Road Access

Two public roads provide access north from M-28 in from Bessemer and Wakefield to the shores of Lake Superior, and are adjacent to the mine site (Figure 6-1). Gogebic County Road (CR) 513 runs north from Bessemer to the Black River Harbor, which is located on the west side of the Black River. The Copperwood Project site is about a mile east-northeast of the Black River Harbor. Extending CR 513 to the Copperwood site would require an estimated 180-foot long bridge over the Black River. The Black River is a National Wild and Scenic River, and therefore construction of a bridge over the river may be problematic in regard to the river designation. Proposing an extension of CR 513 on Federal land (i.e. Ottawa National Forest) would likely require a Special Use Permit and an Environmental Assessment. The CR 513 route to Copperwood would require the construction of about three miles of new road in a relatively roadless area.

Gogebic County Road 519 runs north from M-28 east of Wakefield and is just east of the project site (Figure 6-1). CR 519 would require upgrades if it were to be used for year-round access to the Copperwood site. Upgrades would include replacement of road base to provide drainage, widening the road section and replacement of existing culverts, and installation of asphalt. The length of the reconstruction of CR 519 from M-28 to the Copperwood site is 14 miles and will terminate at the access road entrance to the Copperwood site.

Funding been acquired for the CR 519 reconstruction through the Michigan Department of Transportation (MDOT) with Orvana providing the local matching funds for the project ($2.3M). The CR 519 reconstruction has been permitted by MDEQ.

In order to determine the most appropriate county road access to the Copperwood site, the Gogebic County Road Commission (GCRC) in 2011 conducted a project review process in accordance with MDOT. As a result, GCRC determined that CR 519 was the best alternative route for access to the mine site. The CR 519 route would have the least impact on natural resources because it would not involve any new road to be constructed.

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ACCESS ROAD TO COPPERWOOD SITE
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN

FIGURE 6-1

6.2 Mine Access Road

Several existing logging roads presently provide access to the Copperwood site from CR 519. The Camp 7 Grade road presently provides access to the central part of the proposed mine site; other logging roads off CR 519 provide access to other parts of the project site. Property upon which one of these logging roads is located has been acquired by Orvana for the purpose of constructing a mine access road from CR 519 to the project site.

Camp 7 Grade road is located in the proposed TDF footprint (Alternative 5), so that is not an available route for the mine access road (Figure 6-2). Three other alternative routes were evaluated for the project; the south route; the north route; and the proposed route (Figure 6-3).

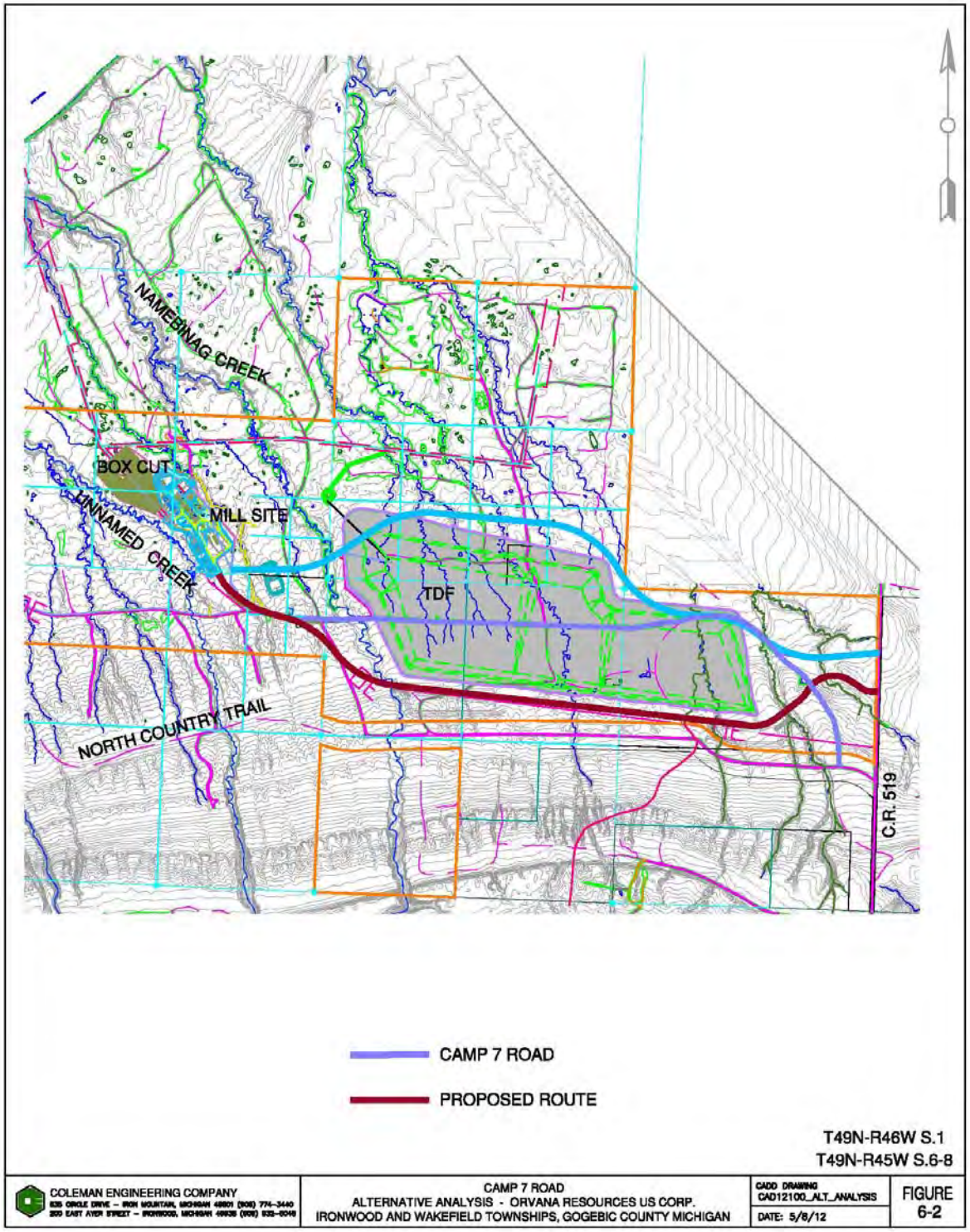
6.2.1 South Route Alternative for the Mine Access Road

The south route, which is the North Country Trail, is mostly owned in fee title by the U.S. Forest Service (USFS), Ottawa National Forest. Any abandonment of the North Country Trail by the USFS would likely require an application for a Special Use Permit and environmental assessment. It would also likely require Orvana to provide and construct a new location for the trail to connect back to the unaffected segments (Figure 6-4).

Due to the likely difficulties with relocating the North Country Trail and the potential adverse public reaction to such a plan, the south route alternative was not investigated further. Wetland impacts were not determined. This alternative was determined by Orvana to be not feasible or prudent, due in large part to the public ownership of most of this route.

6.2.2 North Route Alternative for the Mine Access Road

The north route alternative for the mine access road was initially investigated in an effort to increase the buffer distance from the North Country Trail. Wetland impacts for the north route were determined to be 3.45 acres.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MILL SITE
UNNAMED CREEK
TDF
NORTH COUNTRY TRAIL
C.R. 519
CAMP 7 ROAD
PROPOSED ROUTE
T49N-R46W S.1
T49N-R45W S.6-8
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CAMP 7 ROAD
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN
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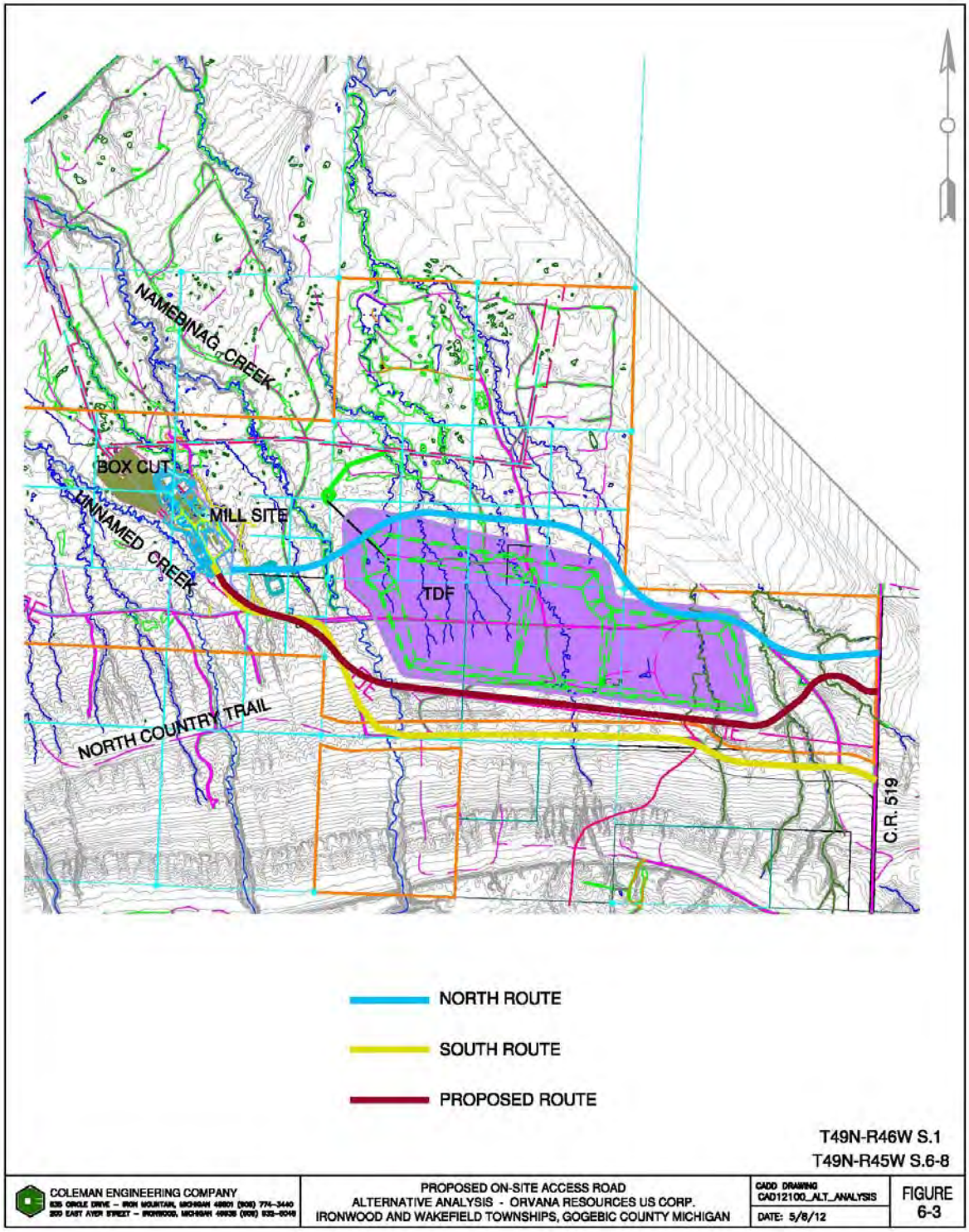
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NORTH ROUTE
SOUTH ROUTE
PROPOSED ROUTE
T49N-R46W S.1
T49N-R45W S.6-8
COLEMAN ENGINEERING COMPANY
PROPOSED ON-SITE ACCESS ROAD
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN
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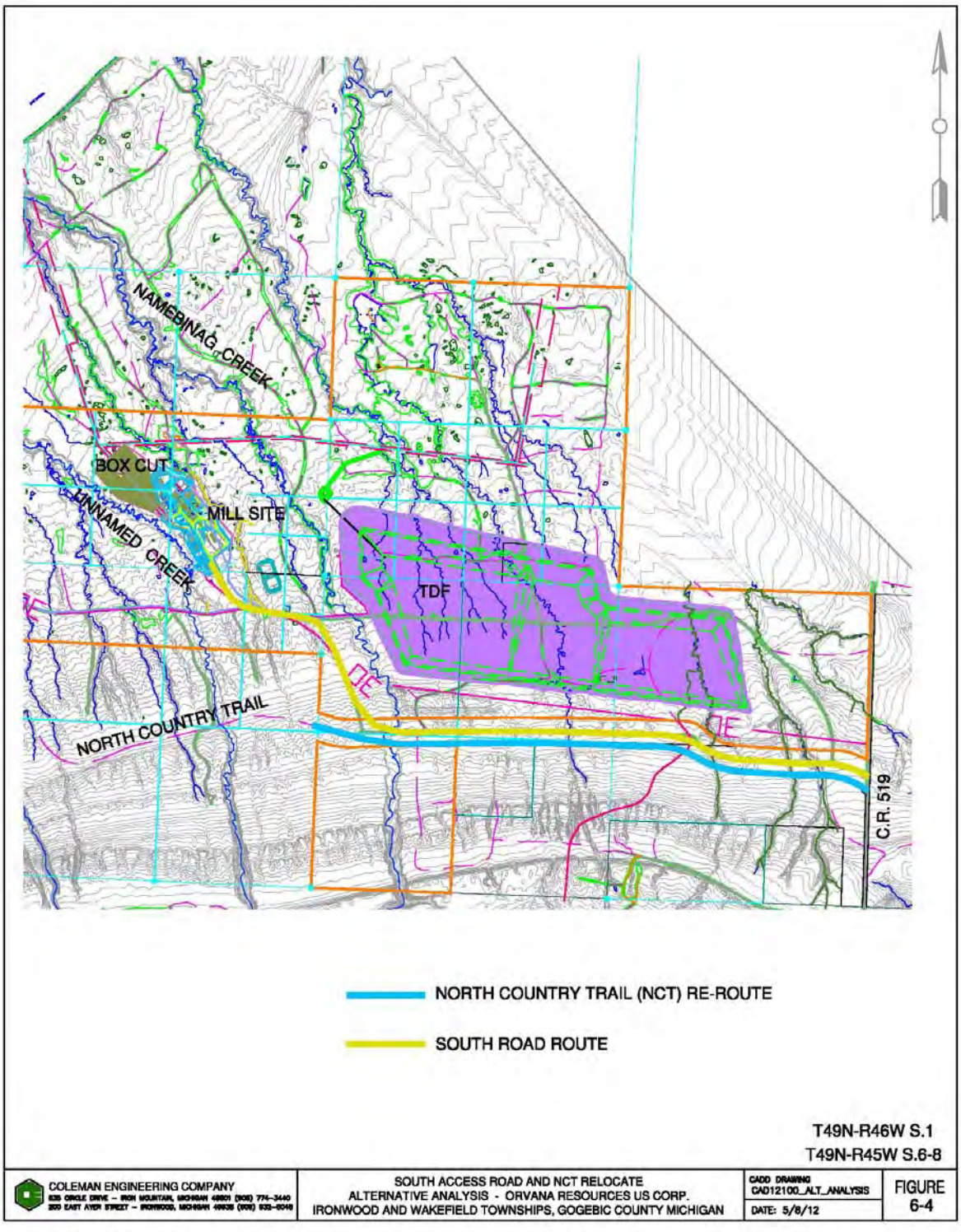
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NORTH COUNTRY TRAIL (NCT) RE-ROUTE
SOUTH ROAD ROUTE
T49N-R46W S.1
T49N-R45W S.6-8
COLEMAN ENGINEERING COMPANY
SOUTH ACCESS ROAD AND NCT RELOCATE
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN
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6.2.3 Proposed (Preferred Alternative) Mine Access Road

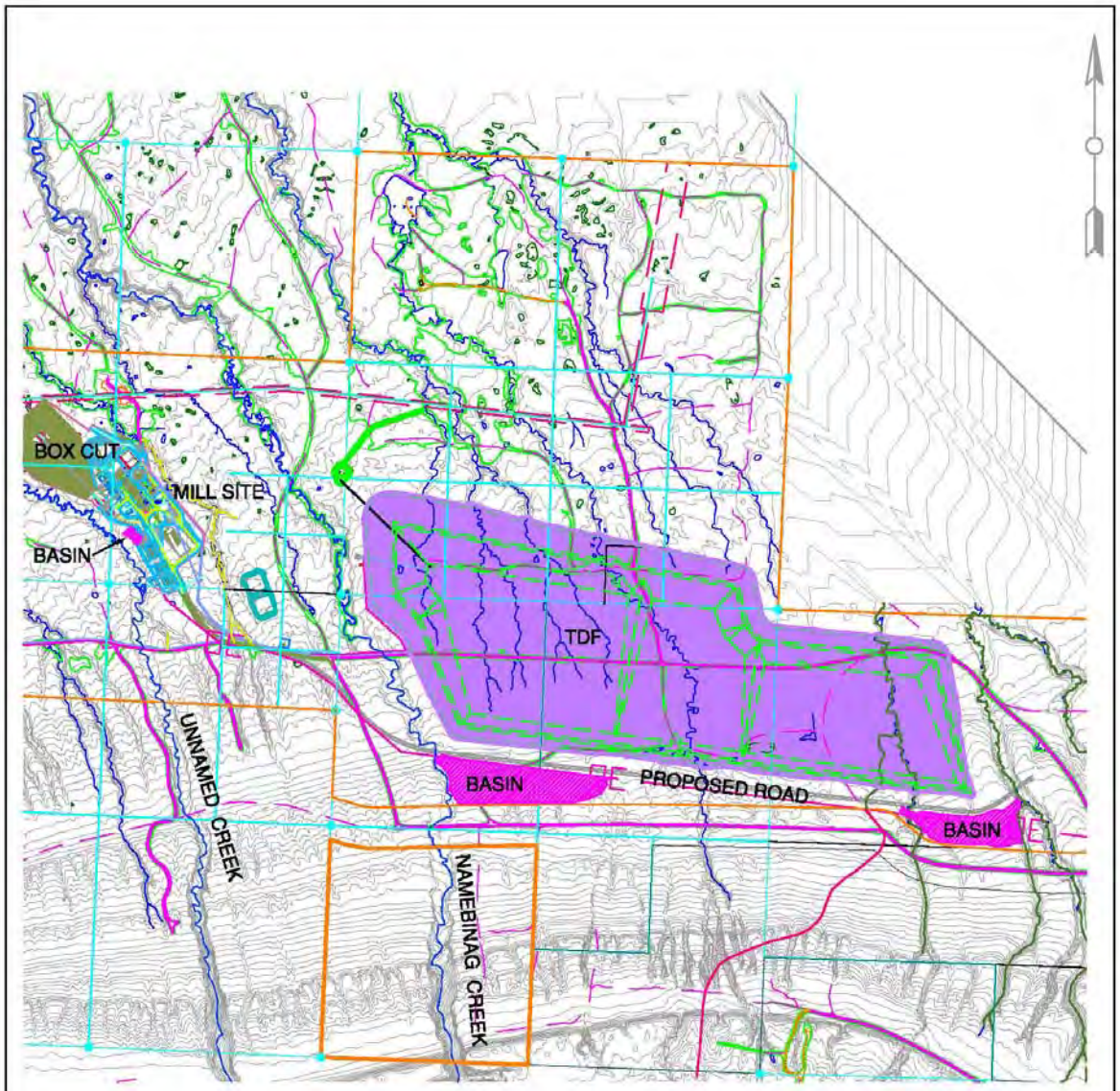
The proposed mine access route is proposed to be connected to CR 519 at a location that provides a safe horizontal and vertical alignment at the intersection with the public road and has more than adequate sight distances. The proposed route is near the south side of the TDF and has a buffer between the access road and the North Country Trail. There are six stream crossings on the proposed route, of which five are existing crossings that will be upgraded and improved by the installation of concrete box culverts. Streams that cross the proposed mine access road are ephemeral streams that have flow only part of the year. Fish do not inhabit these stream segments. Culvert upgrades may have positive impacts on stream conditions downstream. This proposed mine access road would unavoidably impact 2.28 acres of wetlands.

Orvana determined that the proposed mine access road location is the most feasible and prudent road location and would provide the least environmentally damaging practicable alternative of the three mine access road alternatives. Wetland impacts are approximately 0.69 acres more on the north route, and stream impacts are minimized compared to the north route due to the location of the proposed road.

7.0 Detention Basins

There are three proposed stormwater detention basins on the Copperwood site, one at the southeast corner of the TDF, one at the southwest corner of the TDF, and one at the mill site (Figure 7-1). The detention pond at the mill site is 0.31 acres in size and is part of the stormwater collection and treatment system for the mill site. The detention pond at the mill does not impact wetlands and, as such, is not evaluated further in this alternatives analysis.

The basins on the southeast and southwest corners of the TDF are located to provide stormwater detention prior to runoff being discharged to either Gipsy Creek or Namebinag Creek. Ephemeral streams that would be interrupted by the construction of the proposed TDF will discharge into a newly-constructed mitigation wetland that will be created along the south side of the TDF. After runoff enters the mitigation wetland, it will flow to the appropriate east or west detention basins, where runoff will outlet to Gipsy Creek or Namebinag Creek, respectively. Any other location for these two detention basins would not provide stormwater detention for the runoff intercepted by the created wetland prior to discharge to either Gipsy or Namebinag creeks. For these reasons, no other alternative locations are feasible for the east and west detention basins at the TDF. These two detention basins are 5.15 acres and 8.62 acres in size, respectively, and they will impact 0.63 acres of wetlands. Of these 0.63 acres of wetland impacts, there will be 0.16 acres impacted solely by the basins and 0.47 acres in wetlands impacted by both the access road and the two basins. The total access road/detention basin wetland impacts are 2.91 acres.



COLEMAN ENGINEERING COMPANY
635 CIRCLE DRIVE – IRON MOUNTAIN, MICHIGAN 49801 (906) 774-3440
320 EAST AYER STREET – IRONWOOD, MICHIGAN 49938 (906) 932-0048

DETENTION BASINS
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN

CADD DRAWING CAD12100_ALT_ANALYSIS
DATE: 5/8/12

FIGURE 7-1

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8.0 Water Supply Access Road

The GRWA is a municipal authority formed in 1977 under Michigan state law. The GRWA serves portions of Gogebic County with drinking water. The Copperwood Project requires a source of process water and has an agreement with GRWA to install and operate a water intake from Lake Superior. This municipal project will be paid for by Orvana as part of the Copperwood project and will be a needed improvement to the existing water supply in portions of Gogebic County.

The construction of the water intake in Lake Superior requires a permit under both Part 325 (Great Lakes Submerged Lands) of the Michigan Natural Resources and Environmental Protection Act, 1994 Public Act 451, as amended and Section 10 of the 1899 Federal Rivers and Harbors Act. This permit is being applied for by GRWA.

The construction of an access road that will serve the proposed GRWA Lake Superior pump house and associated facilities (e.g. parking) will require the crossing of eight streams and therefore the installation of eight new concrete box culverts to replace existing corrugated metal pipe culverts. One existing culvert will be removed where the existing trail road will be abandoned and the streambed will be restored at that location. The access road will unavoidably impact 0.26 acres of wetland. The GRWA access road is included in this application for permit because that it is a secondary impact of the Copperwood Project.

The GRWA access road, pump house and associated facilities, and approximate pipeline location are shown on Figure 8-1. The location of the pump house and water intake pipe was determined by GRWA.

The road location was carefully evaluated to avoid and minimize impacts to the extent practicable; 0.26 acres of wetland would be impacted by the proposed road.

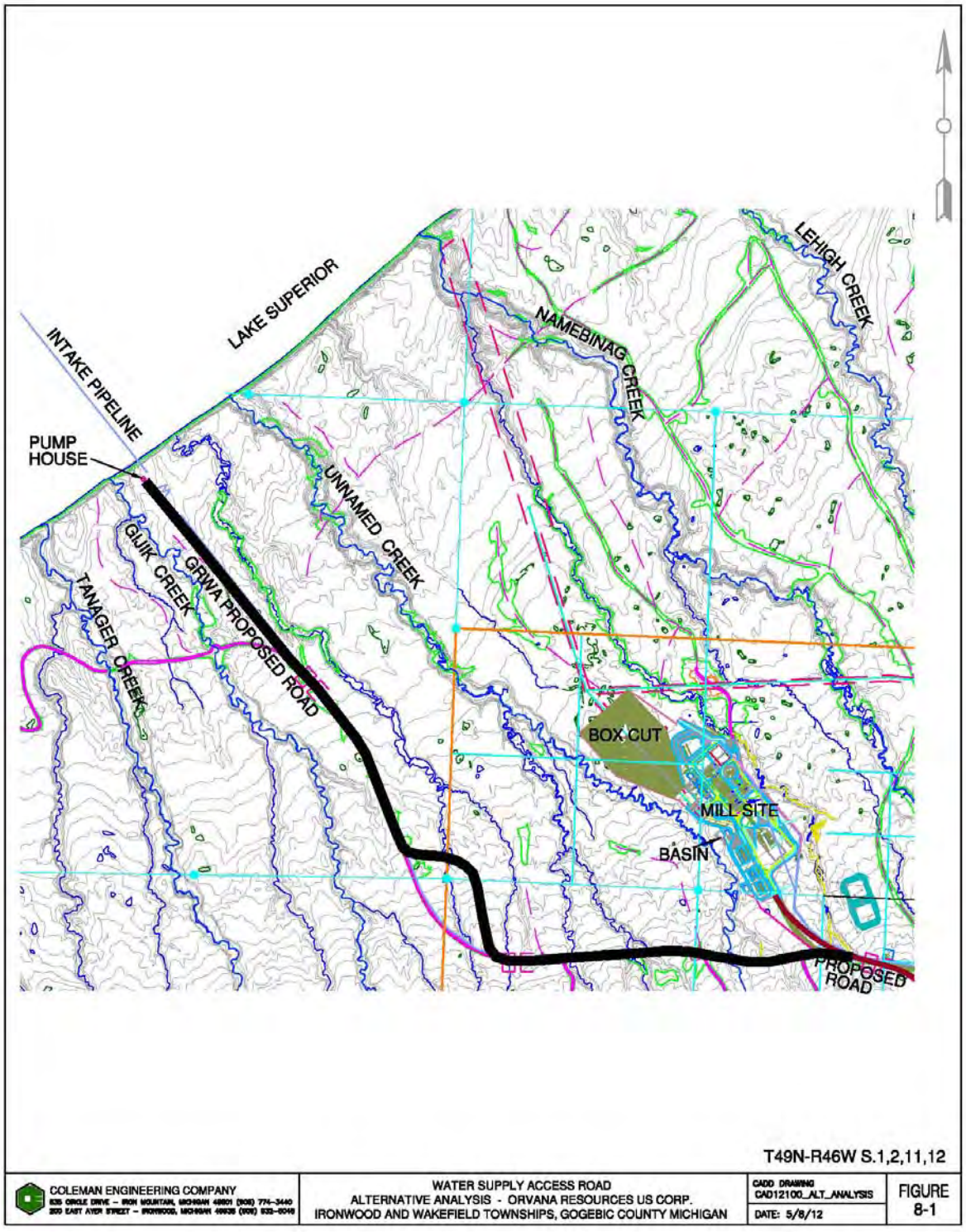
LAKE SUPERIOR
INTAKE PIPELINE
PUMP HOUSE
NAMEBINAG CREEK
LEHIGH CREEK
UNNAMED CREEK
GIJIK CREEK
TANAGER CREEK
GRWA PROPOSED ROAD
BOX CUT
MILL SITE
BASIN
PROPOSED ROAD
T49N-R46W S.1,2,11,12
COLEMAN ENGINEERING COMPANY
WATER SUPPLY ACCESS ROAD
ALTERNATIVE ANALYSIS - ORVANA RESOURCES US CORP.
IRONWOOD AND WAKEFIELD TOWNSHIPS, GOGEBIC COUNTY MICHIGAN
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FIGURE 8-1
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9.0 Summary of Alternatives

The proposed activity on the Copperwood Project in regard to wetland impacts that has the most potential alternatives is the TDF. In addition, the proposed TDF will result in the largest amount of wetland and stream impacts. Of the remaining five activities, three (i.e. mine entrance, mill, and detention basins) do not have feasible and prudent alternatives and two (i.e. mine access road and water supply access road) have very limited alternatives.

The proposed location of the TDF has been thoroughly analyzed due to its importance to the economic viability of the Copperwood Project, the amount of wetland and stream impacts, and the safety of the mining operations. With the demonstration of the avoidance and minimization of wetland and stream impacts while taking into consideration the practicability of any given alternative that has been presented in this alternatives analysis, Orvana is committed to efforts focusing on the wetland and stream mitigation to offset the unavoidable impacts of the project.

The impacts of all alternatives and the resultant impacts are summarized in Table 9-1.

Table 9-1. Summary of Impacts for all Projects for the Copperwood Project

Alternative	Wetland Impact (ac)	Stream Impact (LF)	Estimated Cost
Box Cut	1.39	0	
Mill Site	2.27	0	
TDF Alternative 1	39.75	5,863	$69,333,333
TDF Alternative 2	NA	NA	NA
TDF Alternative 3	16.69	3,877	$20,670,000
TDF Alternative 4	51.84	13,672	$104,670,000
TDF Alternative 5	51.84	13,672	$102,270,000
TDF Alternative 6	8	4,025	NA+$150,000,000*****
TDF Alternative 7	26	7,374	NA+$100,000,000*****
TDF Alternative 8	42	16,530	NA +$65,000,000*****
TDF Alternative 9	NA	NA	$3.7M to $7.6M
Mine Access Road and Detention Basins	2.91	0	$5,340,185
Water Supply Access Road	0.26	0	NA

*****Cost NA + means total cost not available with additional incremental cost for obtaining off-site dike material.